

Review of Coal Power

August 18, 2005



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Overview of Coal Power

- ◆ The fundamentals of coal power are attractive
 - New technologies improve efficiency and are lower emitting
 - Coal reserves are abundant
 - Fuel prices are stable
 - Transportation costs are lowering

- ◆ However, given the current state of technology and California's regulation and market environment, it is highly unlikely new investments in coal (or any other non-renewable capital intensive technology) will be made any time soon
 - No retail customer business is sufficiently stable to warrant investment or long-term contracting
 - Merchant generation is still not feasible
 - CO2 sequestration is an immature technology



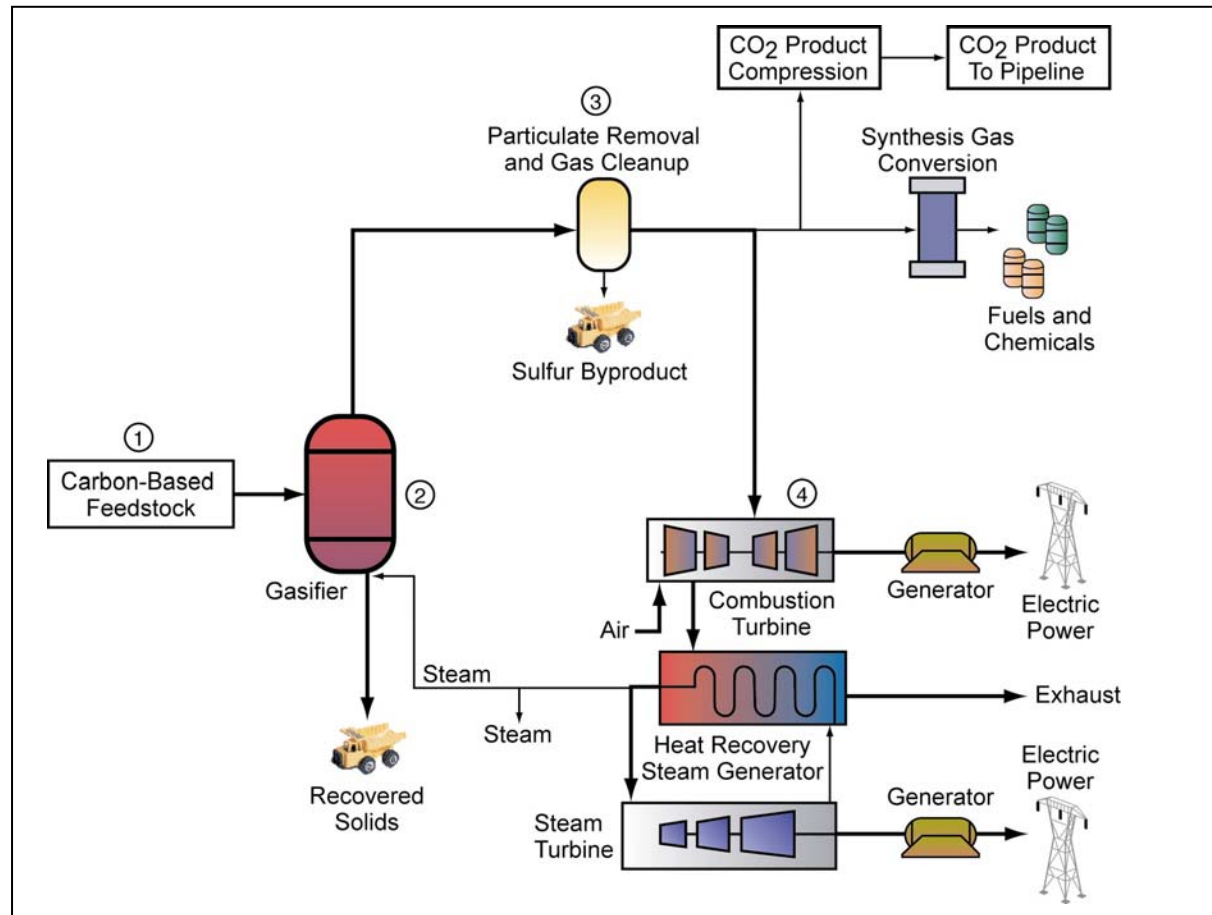
New technologies reduce emissions and improve efficiency.

- ♦ **Coal Gasification** is a process that converts solid coal into a synthetic gas, which can be fired into a CCGT gas turbine, making it more efficient than a conventional coal boiler plant which only uses a steam turbine.
- ♦ **Fluidized Bed Combustion (FBC)** is a process of burning coal in which the coal is inserted in a bed of particles that are suspended in the air and react with the coal to heat the furnace more cleanly.



Integrated Gasification Combined Cycle (IGCC)

1. Coal is fed into the gasifier
2. Carbon molecules in coal are partially oxidized to produce syngas.
3. Syngas is cooled and cleaned to remove particulates.
4. The syngas is fired into the combustor of the CCGT.



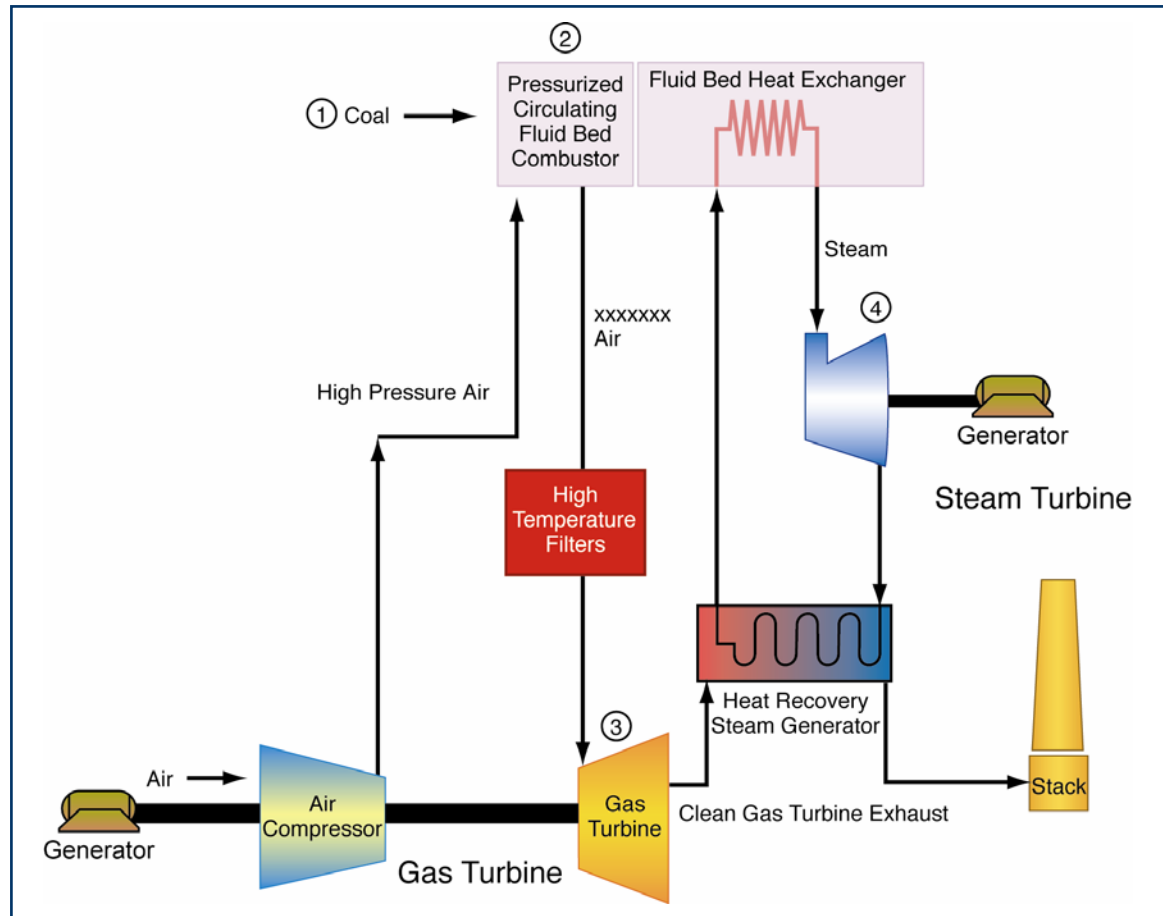
Source: http://www.fossil.energy.gov/images/programs/powersystems/gasification_schematic.jpg



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Fluidized Bed Combustion (FBC)

1. Fuel is inserted into the fluidized bed combustor.
2. The scrubbing action of the bed material strips away the carbon dioxide and char layers.
3. A concentrated gas stream is produced from the FBC, and it is sent to a gas turbine.
4. Steam generated from the heat in the fluidized bed is sent to a steam turbine, creating a highly efficient combined cycle system.

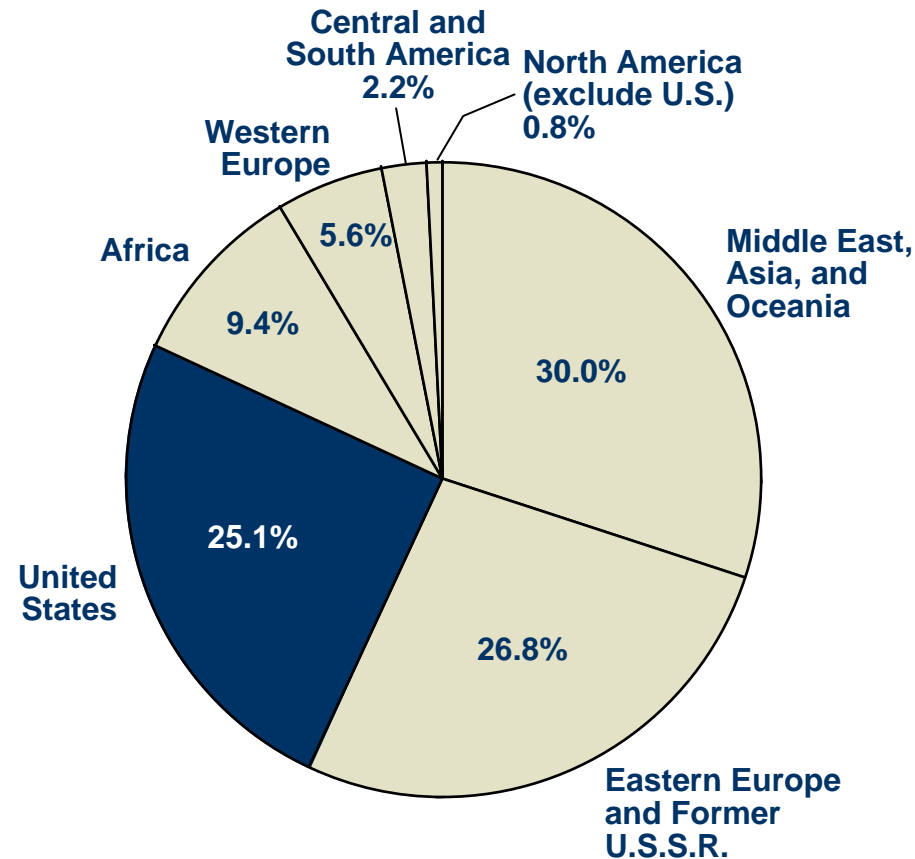


Source: <http://www.netl.doe.gov/coal/combustion/FBC/images/pfb1.jpg>;
<http://www.netl.doe.gov/coal/combustion/FBC/fbc-overview.htm>

The United States has more than 270 million tons of recoverable coal reserves, which has the potential to provide 534 trillion kWh of electricity.

World Recoverable Reserves of Coal (Million Tons)

100% = 1,081,268 million tons



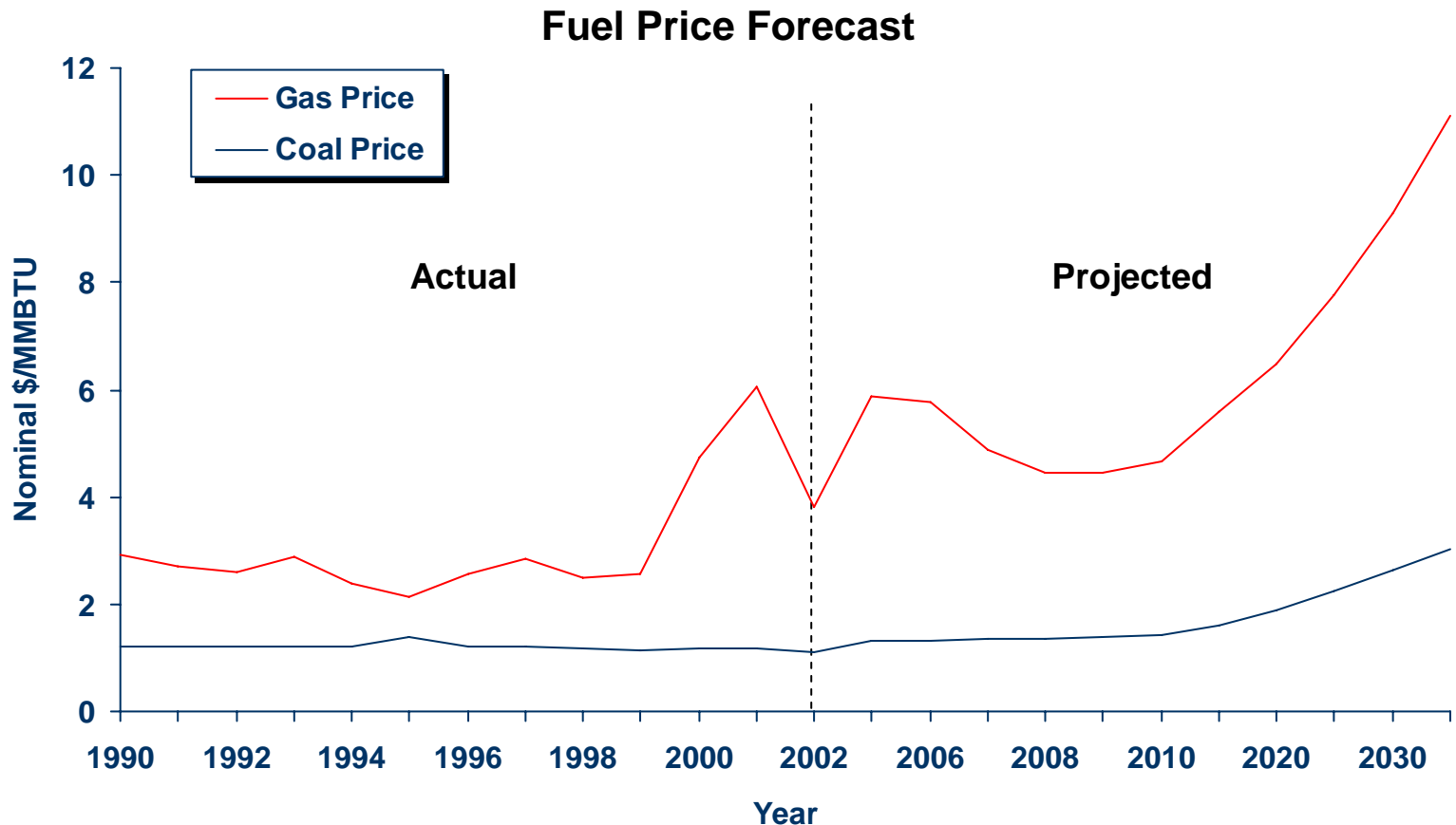
Source: <http://www.eia.doe.gov/aer/txt/ptb1113.html>
<http://www.ceednet.org/ceed/index.cfm?cid=7500,7584>

Note: U.S. data are more current than other data on this table. They represent recoverable reserves as of December 31, 2002; data for the other countries are as of December 31, 2000, the most recent period for which they are available.



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Coal is a low price, low volatility fuel option when compared to natural gas.



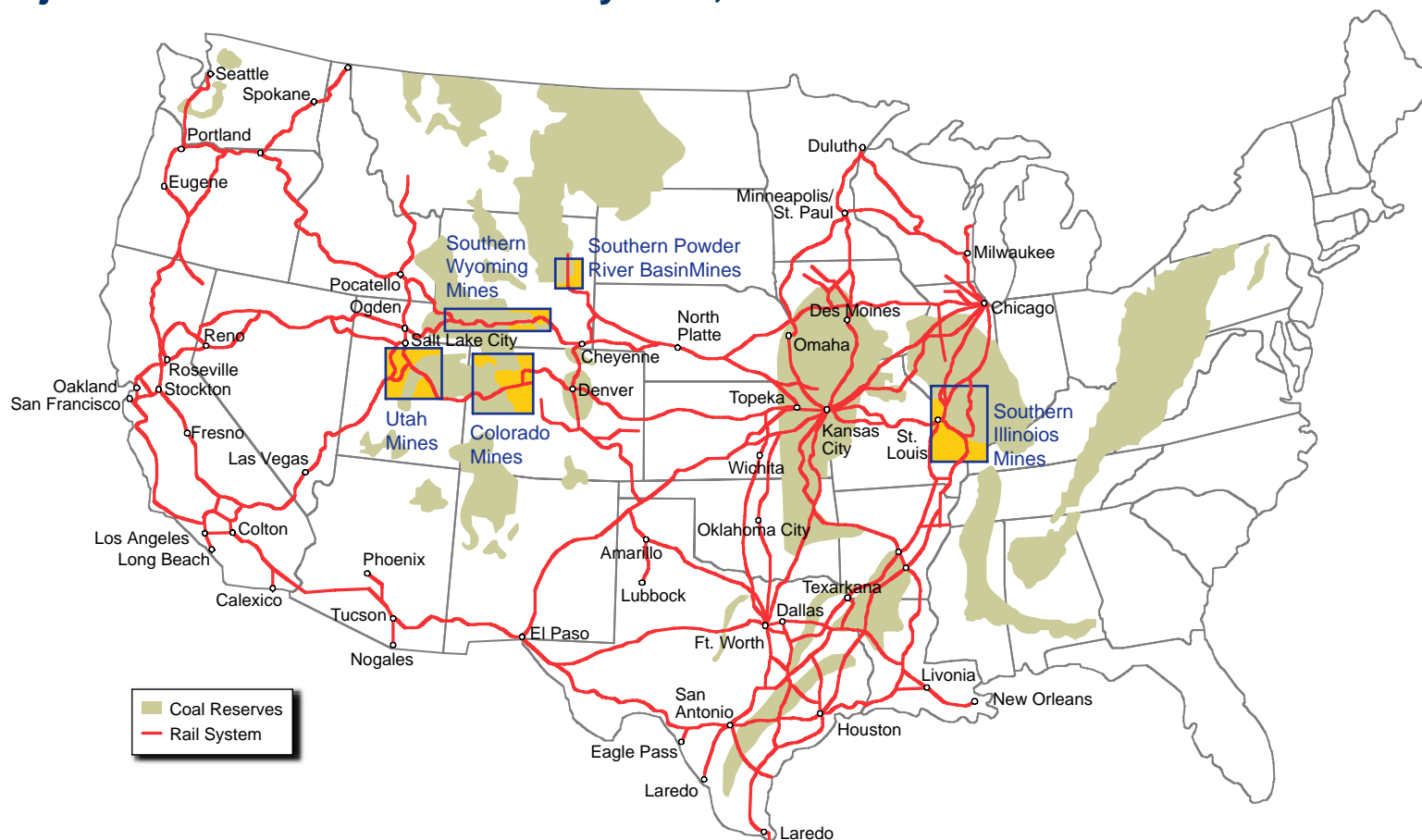
Source: Gas Price from Global Insight Forecast, Fall 2004
Coal Price Forecast from EIA Annual Energy Outlook 2004
<http://www.eia.doe.gov/cneaf/electricity/page/ferc423.html>
http://www.eia.doe.gov/cneaf/electricity/epm/matrix96_2000.html



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Existing rail system makes it convenient to deliver coal throughout the western U.S.

Major U.S. Coal Mines and Rail System, 2003



- The average haul for coal has risen steadily in recent years, from 558 miles in 1992 to 696 miles in 2001.

Source: <http://www.eia.doe.gov/cneaf/coal/page/acr/table9.html>

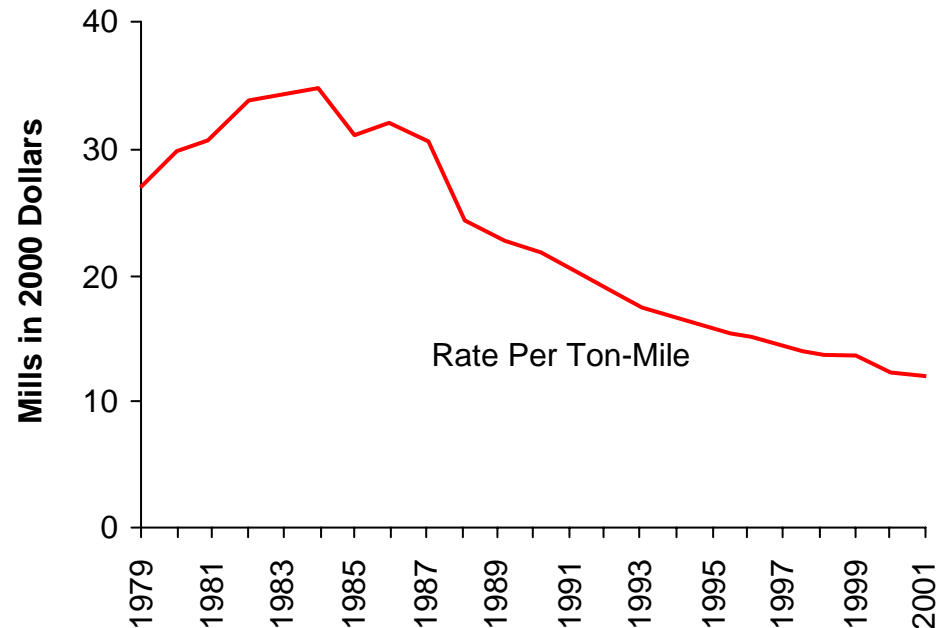


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Coal has low transportation rates, making it inexpensive to deliver to coal plants.

Trends in Coal Transportation Rates, 1979–2001



To transport coal from Laramie, Wyoming, to Needles, California (968 miles) in Year 2001, it would cost approximately $\$0.012/\text{ton-mile} \times 968 \text{ miles} / 10,000 \text{ BTU/lb.} = \0.58 per mmbtu

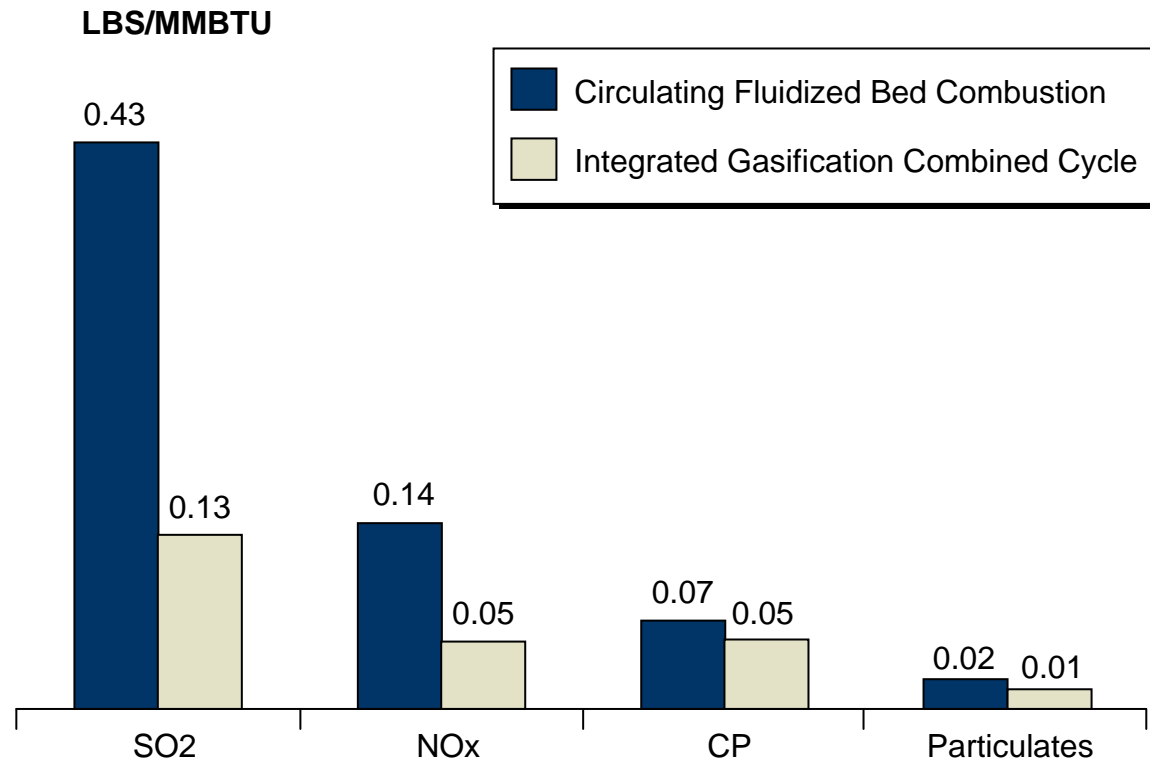
Source: Energy Information Administration, Coal Transportation Rate Database, April 2004.
<http://www.eia.doe.gov/cneaf/coal/page/trans/fig2.01.gif>



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An IGCC power plant produces marketable byproducts, rather than large volumes of solid wastes typical of fluidized bed combustion power plants.

Air Emissions of IGCC vs. Fluidized Bed Power Generation Using Petroleum Coke



Source: http://www.gasification.org/fr_04.gif

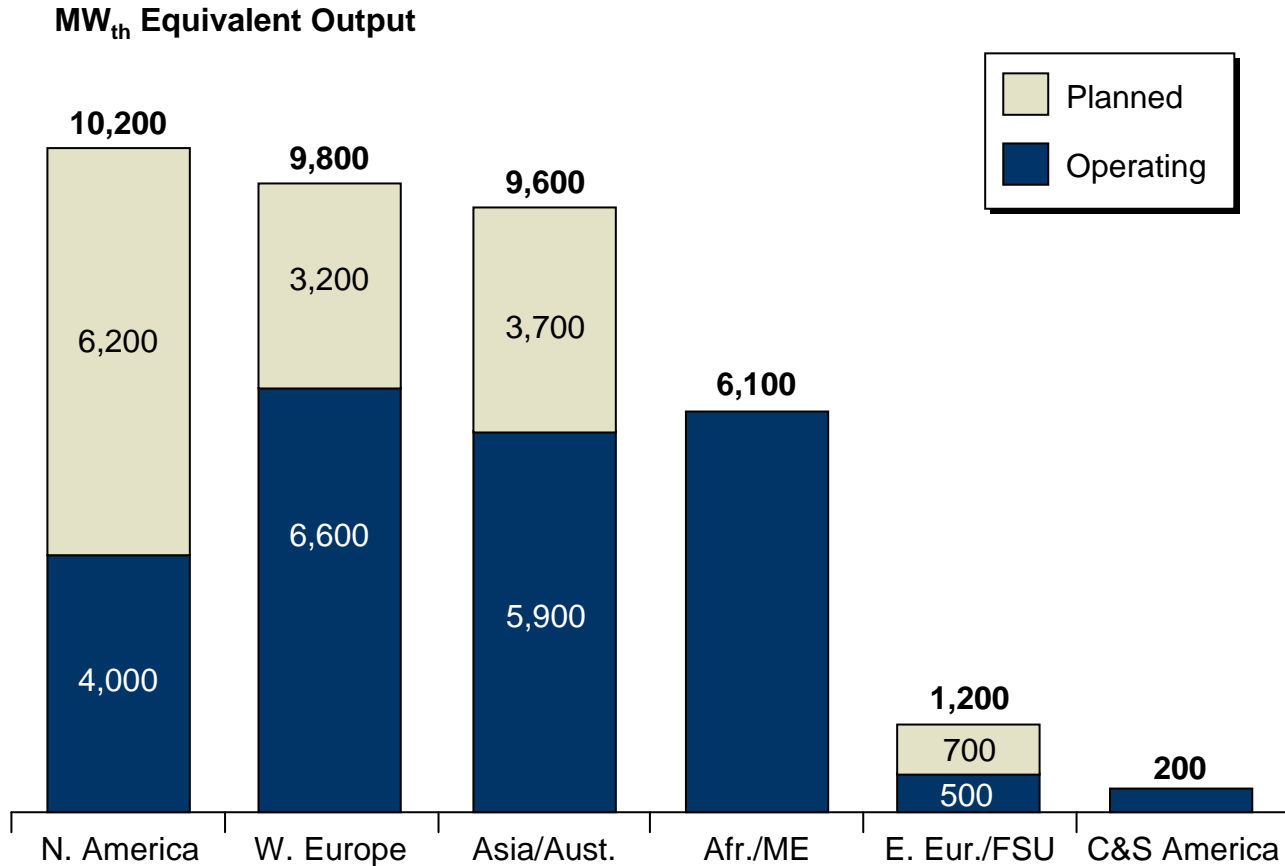


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Market interest in IGCC power plants is significant.

Geographical Distribution of World Gasification Capacity



Source: http://www.gasification.org/Docs/2004_Papers/06CHIL.pdf



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Existing IGCCs in the U.S.

Power Plant	Capacity	Efficiency	Start Year	\$/kW
Wabash River Repowering Project	292 MW	40-45%	1995	\$1,500
Polk Power Station	250 MW	40-42%	1996	\$2,420
Pinion Pine Power Plant	107 MW	40-45%	1998	\$2,060



Typical installed regular coal plant
has efficiency of 33–38%

Source: http://www.energy.gov/engine/content.do?PUBLIC_ID=13001&BT_CODE=PR_PRESSRELEASES&TT_CODE=PRESSRELEASE
http://www.worldenergy.org/wec-geis/publications/default/tech_papers/17th_congress/2_3_28.asp (pinion)
<http://www.netl.doe.gov/cctc/factsheets/tampa/tampaedemo.html>

Note: \$/kW is calculated based on total amount spent



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Interest in IGCC technology is strong and accelerating.

♦ GE forms venture to build IGCCs.

- It has announced plans for GE Energy to acquire ChevronTexaco's gasification technology business. (May 2004)
- GE and Bechtel Corporation have signed a letter of intent to study the feasibility of constructing a 500-600 MW IGCC generating station. (October 2004)

♦ American Electric Power builds IGCC

- AEP has planned investments of \$5 billion in its current generation fleet by 2020 to reduce emissions.
- Estimates for engineering and constructing a large scale IGCC plant are as low as \$1,300 per kilowatt. (September 2004)

♦ Black & Veatch and Uhde Pursue Clean Coal Projects.

- The alliance will facilitate commercial offerings for engineering, procurement, and construction of gasification and IGCC projects. (November 2004)
- Black & Veatch Corporation is a leading global engineering, consulting and construction company specializing in infrastructure development in the fields of energy, water, and information.
- Uhde is one of the world's leading engineering companies in the design and construction of chemical, refining, and other industrial plants. It has designed the built the world's largest, single unit IGCC power plant in Spain.

Source: www.gasification.org/Docs/2004_papers/07LOWE.pdf
Booz Allen Hamilton Final Report, September 3, 2004
<http://www.fossil.energy.gov/programs/powersystems/cleancoal/index.html>



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Government Programs such as the Clean Coal Initiative encourages the development of IGCC technology.

- ◆ The Energy Policy Act of 2003 authorizes \$2 billion for 2005-2012 for generation and pollution control project.
 - The Initiative authorizes \$200 million per year 2004-2012, requiring at least 60% for gasification technology. Projects include:
 - 1) \$557 million IGCC Plant in Florida
 - DOE will contribute \$235 million for the 285 MW plant. Expected date for commercial operation is in early 2010.
 - The Stanton plant would be the second significant IGCC installation in Florida, joining Tampa Electric's 250 MW Polk Power Plant in Polk County, also developed with DOE funding.
 - 2) Mesaba Energy Project
 - The first unit of the project will be capable of producing a net output of approximately 532 MW of electricity.
 - It will begin operations in 2010.

Source: www.gasification.org/Docs/2004_papers/07LOWE.pdf



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Coal technology has advantages and disadvantages.

Pros	Cons
<ul style="list-style-type: none">♦ Inexpensive♦ Advances in emission technology reduces more air pollutants than existing coal plants♦ More efficient than existing coal plants♦ Reduction in U.S. dependence upon imported fuels for economic security.♦ Provides fuel diversity	<ul style="list-style-type: none">♦ More carbon emission than gas (but carbon sequestration can mitigate this problem)♦ New technology can lead to unknown problems♦ High capital cost♦ Transmission and location problems



Hurdles for New Coal Plant Development to Meet California's Needs

- ◆ The current, uncertain state of retail competition for most entities in California may not support new coal plant investment
 - Coal power, regardless of technology type, requires a substantial capital investment that will be difficult to justify to utilities who have unbalanced incentives and uncertain ability for cost recovery
 - Similarly, the merchant generation business is out of the question for such an investment
 - Finally, no load serving entity has sufficiently long commitments from customers to justify a long-term contract that will provide an independent generator cost recovery for such an investment
- ◆ Although sequestration technology has been proven, it is has not yet been standardized
 - A lack of standardization and dependable operating hours make this technology relatively immature

